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OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

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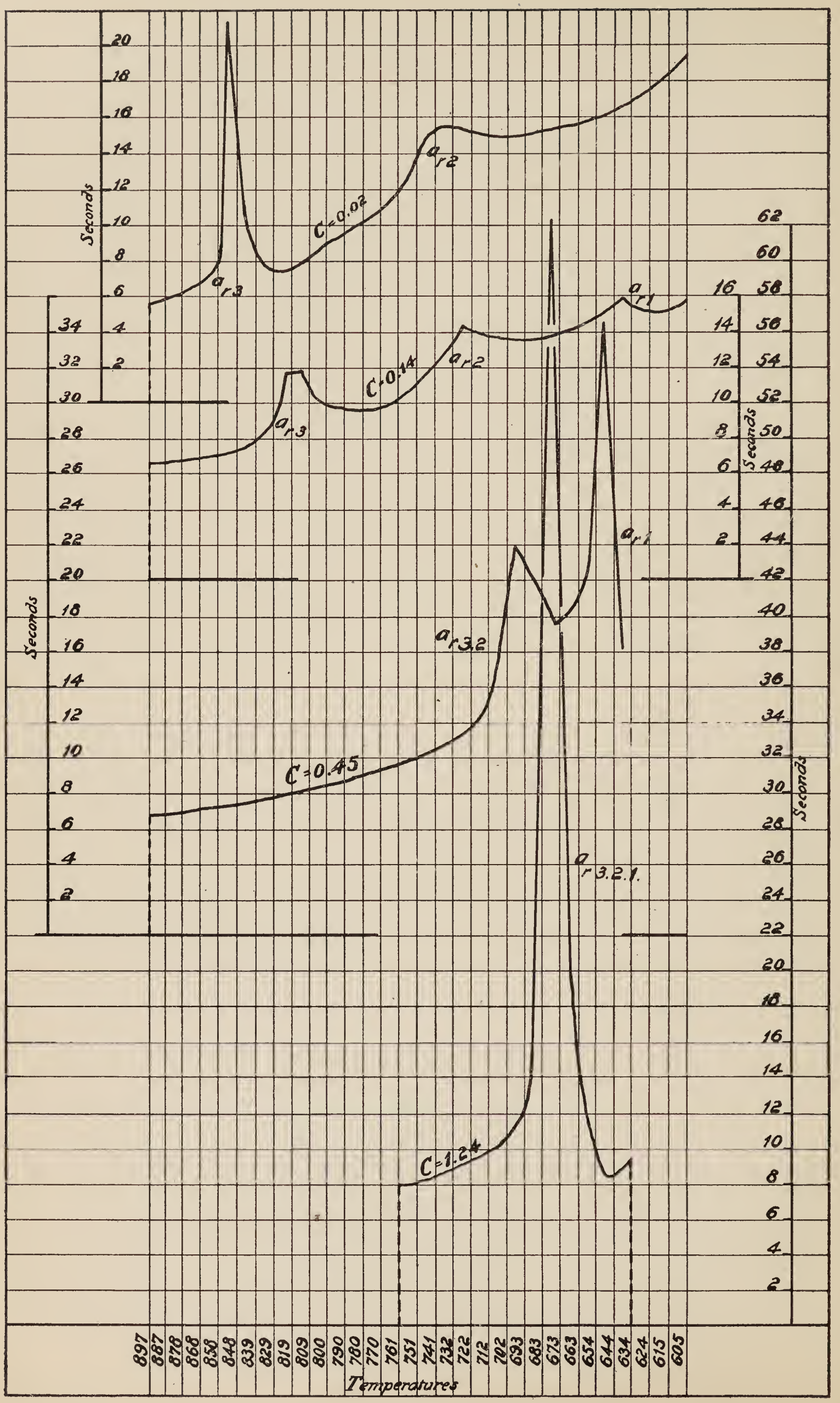


RECALESCENCE OF STEEL.

RAIL AS CAMBERED BY MACHINE, AFTER LEAVING THE HOT SAW.

10"

RECALESENCE OF BASE.

4½"

6 to 8"

RECALESENCE OF HEAD.

16" TO 20"

IDEAL SURFACE COOLING.

30 FT.

COMMON TYPES OF ACTUAL SURFACE COOLING.

HOT BED LEVEL

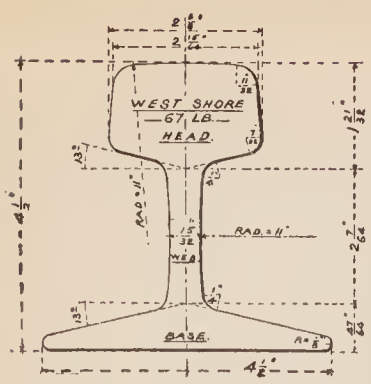
CROSS SECTION OF NEARLY HALF OF HOT BED.

15" 2'-6" 4'-0"

CARRIAGE WAY.

IDEAL SIDE COOLING.

TYPES OF ACTUAL SIDE COOLING.



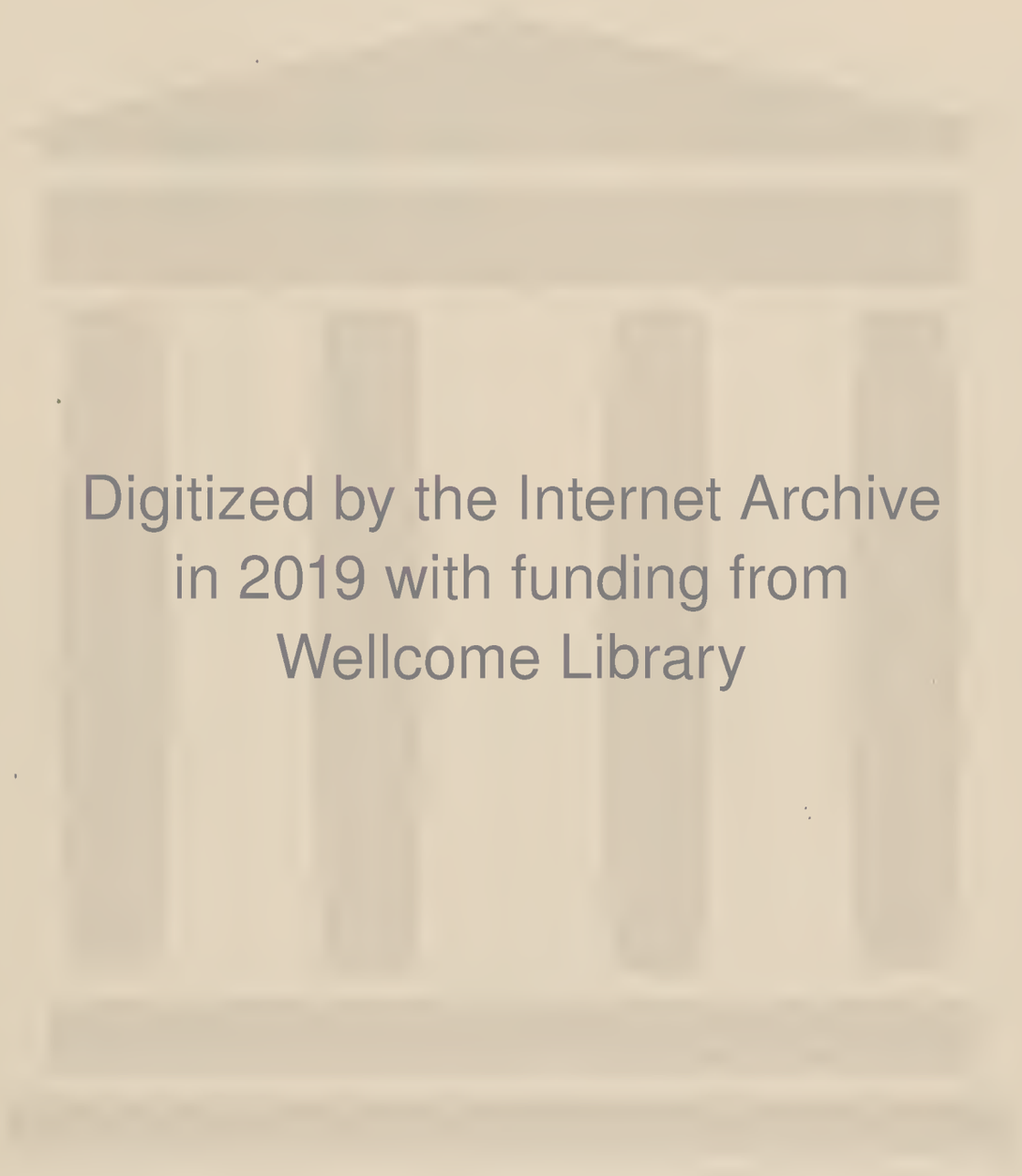
PROPORTIONATE AREAS.	
HEAD	51.04%
WEB	16.87 "
BASE	32.09 "
	100.00 "

COOLING OF UNBALANCED RAIL SECTIONS ON THE HOT BED, RAILS SPACED 6 TO 8 INCHES APART.

RAILS BUNCHED, OR NOT SPACED, THE CURVES WOULD BE MORE IRREGULAR THAN THOSE ABOVE SHOWN.

SCALES:
HORIZONTAL..... 1 : 36 .....
VERTICAL..... 1 : 9 FOR RAIL.
..... DO. ..... 1 : 18 - CAMBER

P. H. DUDLEY. C.E.
80 PINE ST., NEW YORK.



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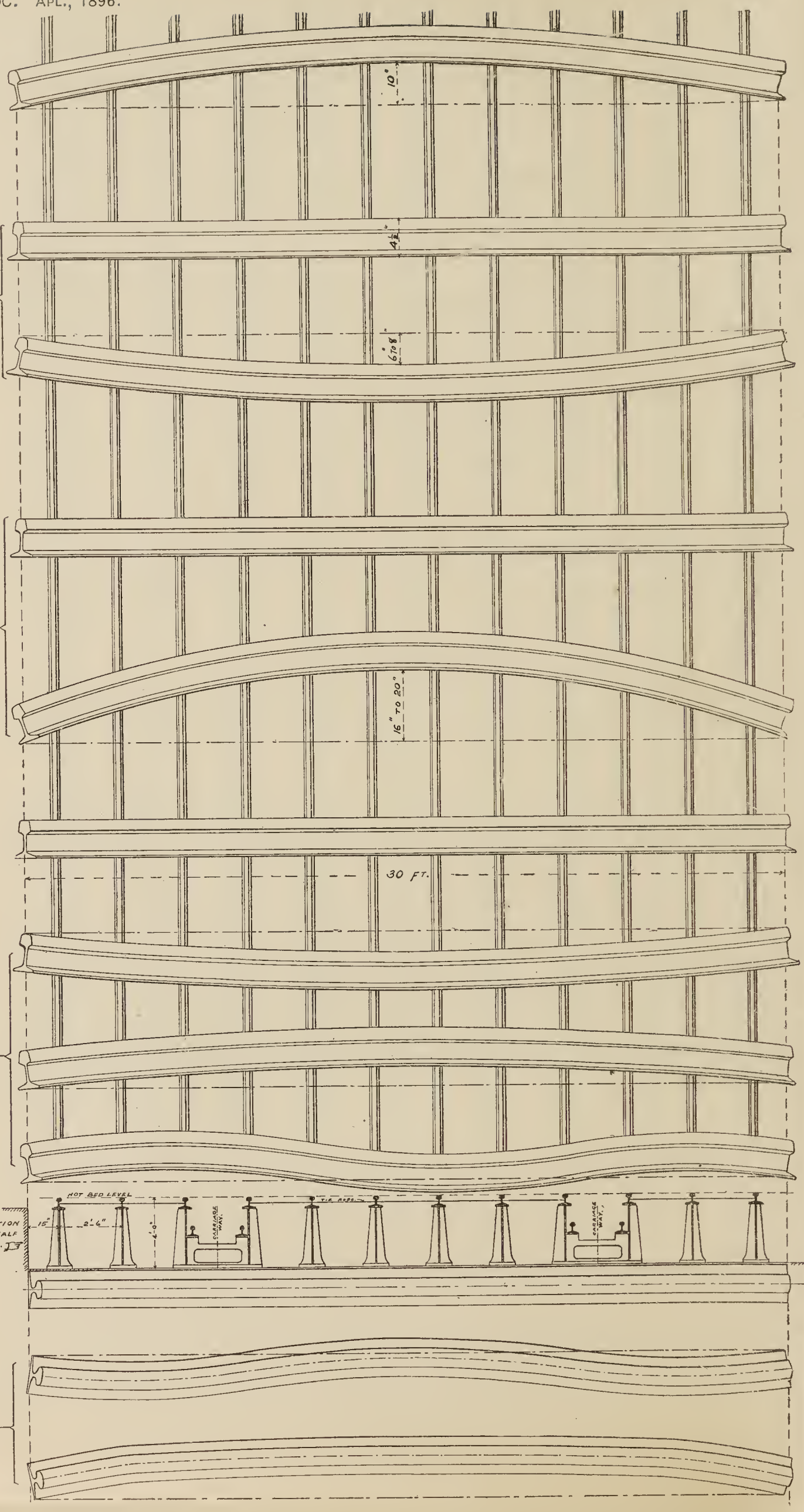

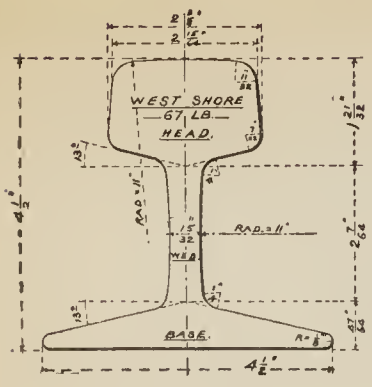

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HORIZONTAL..... 1 : 36 .....
VERTICAL..... 1 : 9 FOR RAIL
.....DO..... 1 : 18 = CAMBER

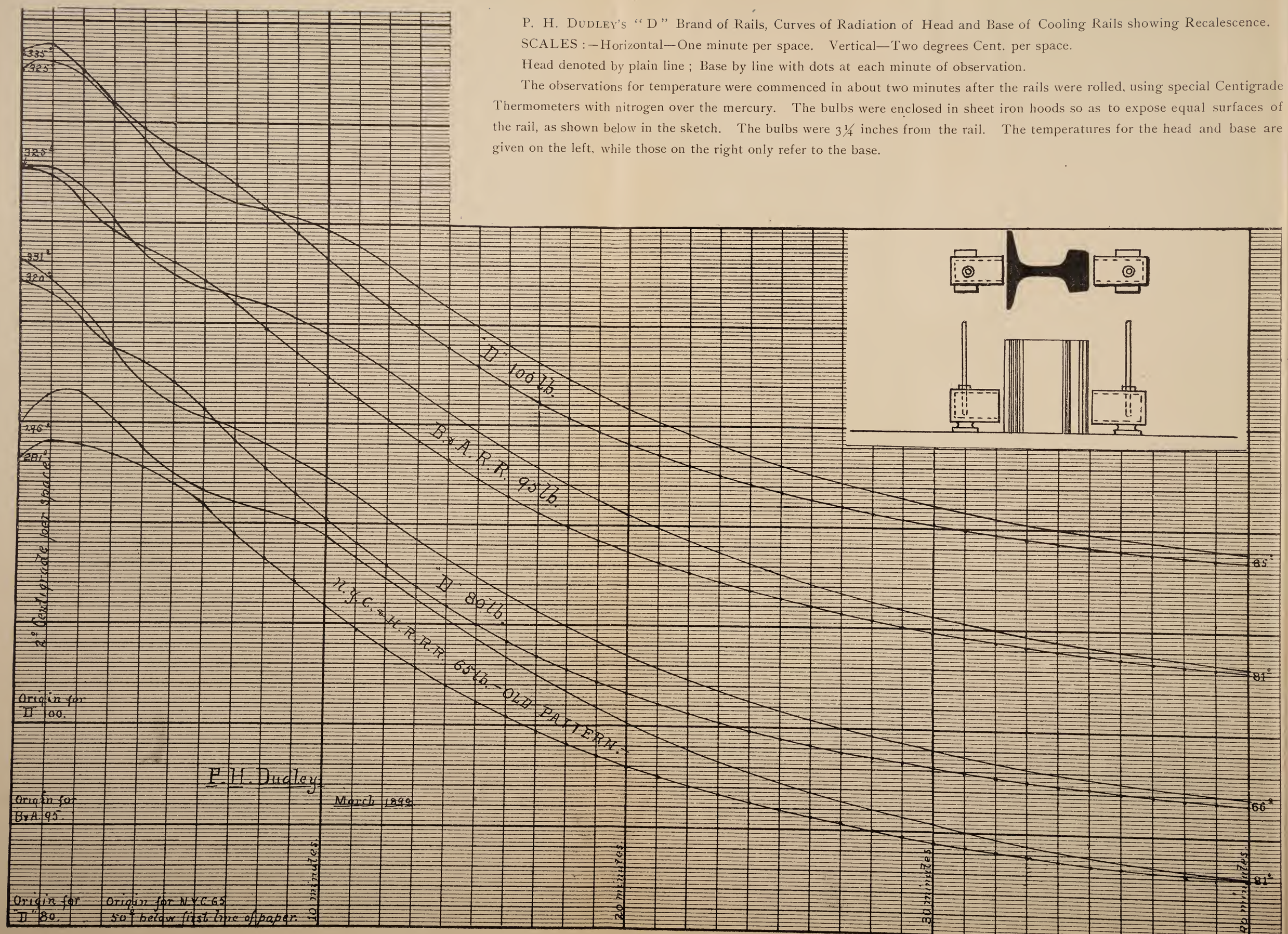
P. H. DUDLEY. C.E.
80 PINE ST., NEW YO

P. H. DUDLEY'S "D" Brand of Rails, Curves of Radiation of Head and Base of Cooling Rails showing Recalescence.

SCALES :—Horizontal—One minute per space. Vertical—Two degrees Cent. per space.

Head denoted by plain line ; Base by line with dots at each minute of observation.

The observations for temperature were commenced in about two minutes after the rails were rolled, using special Centigrade Thermometers with nitrogen over the mercury. The bulbs were enclosed in sheet iron hoods so as to expose equal surfaces of the rail, as shown below in the sketch. The bulbs were 3¼ inches from the rail. The temperatures for the head and base are given on the left, while those on the right only refer to the base.



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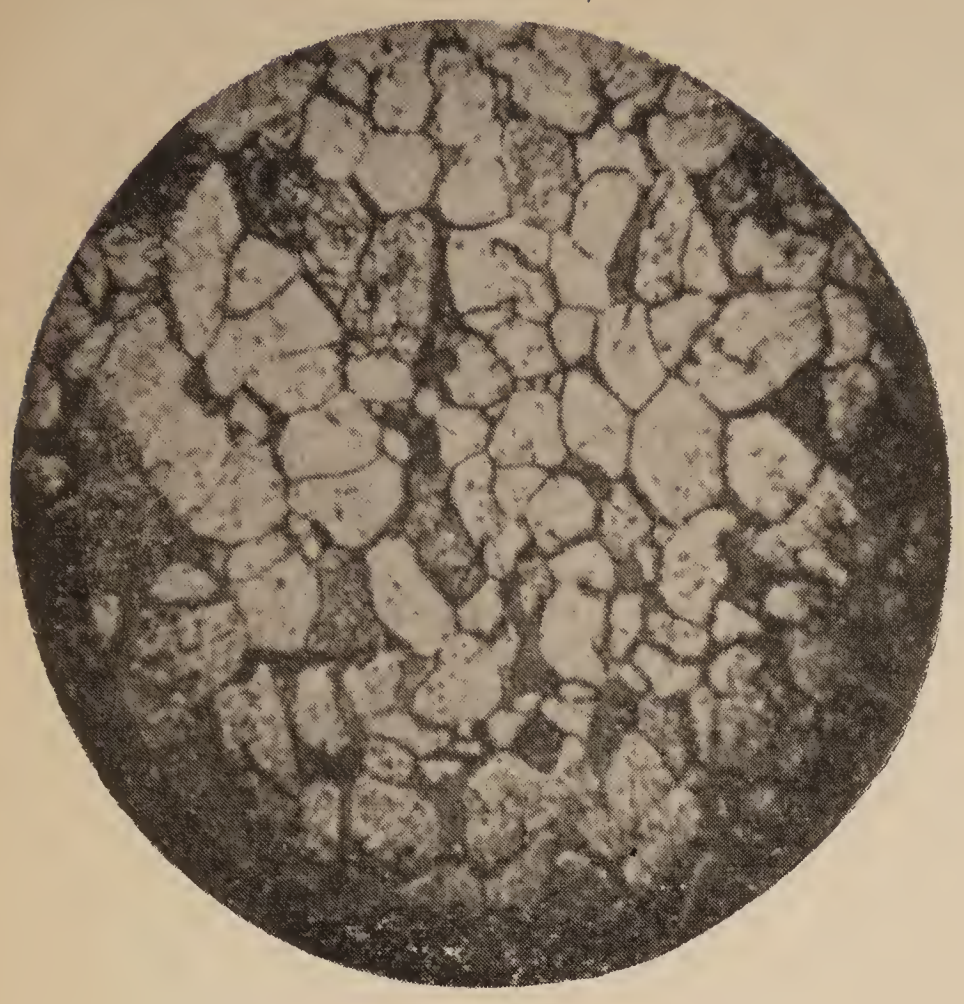


FIG. 159.

FIG. 157.

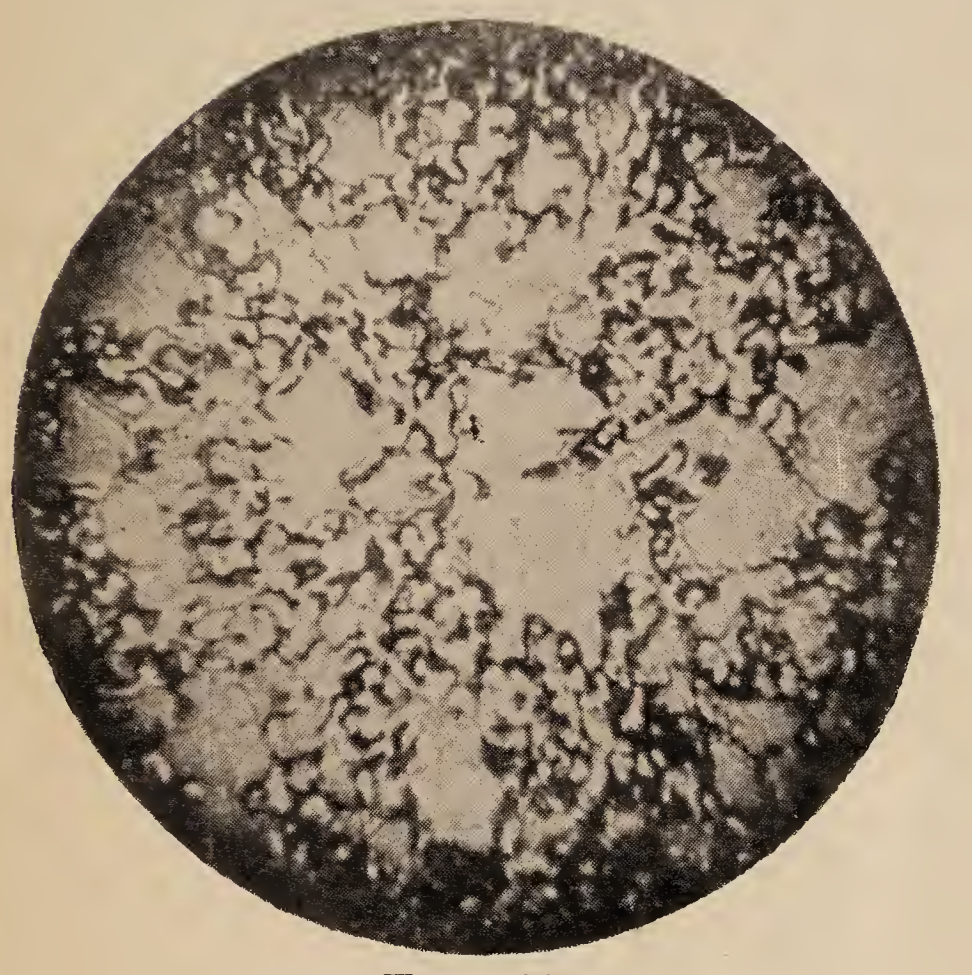


FIG. 208.

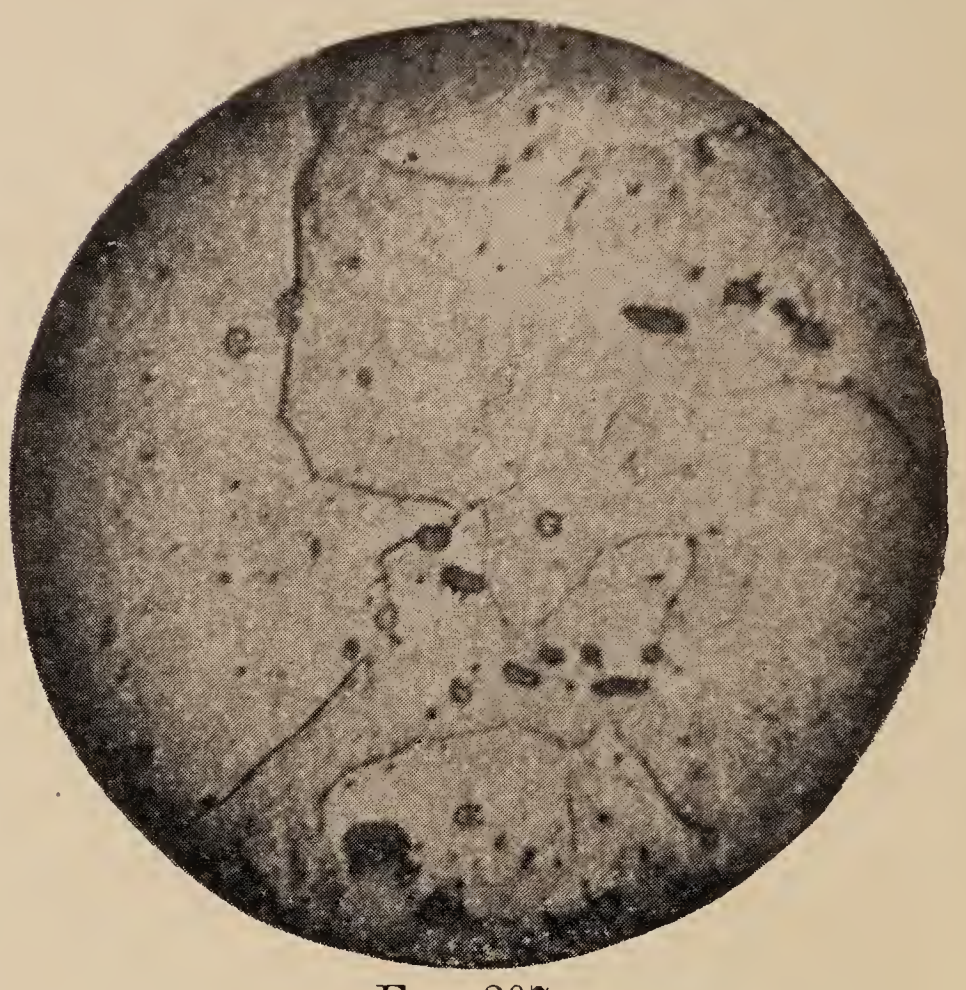


FIG. 307.

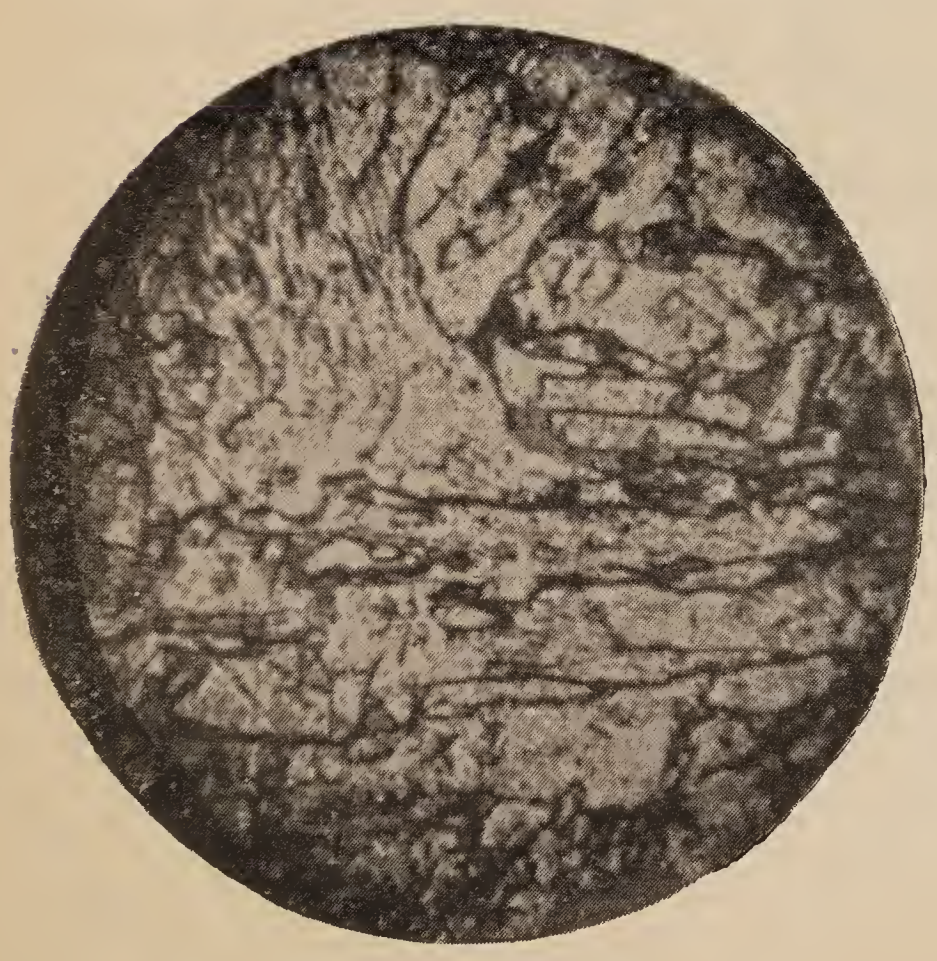


FIG. 160.

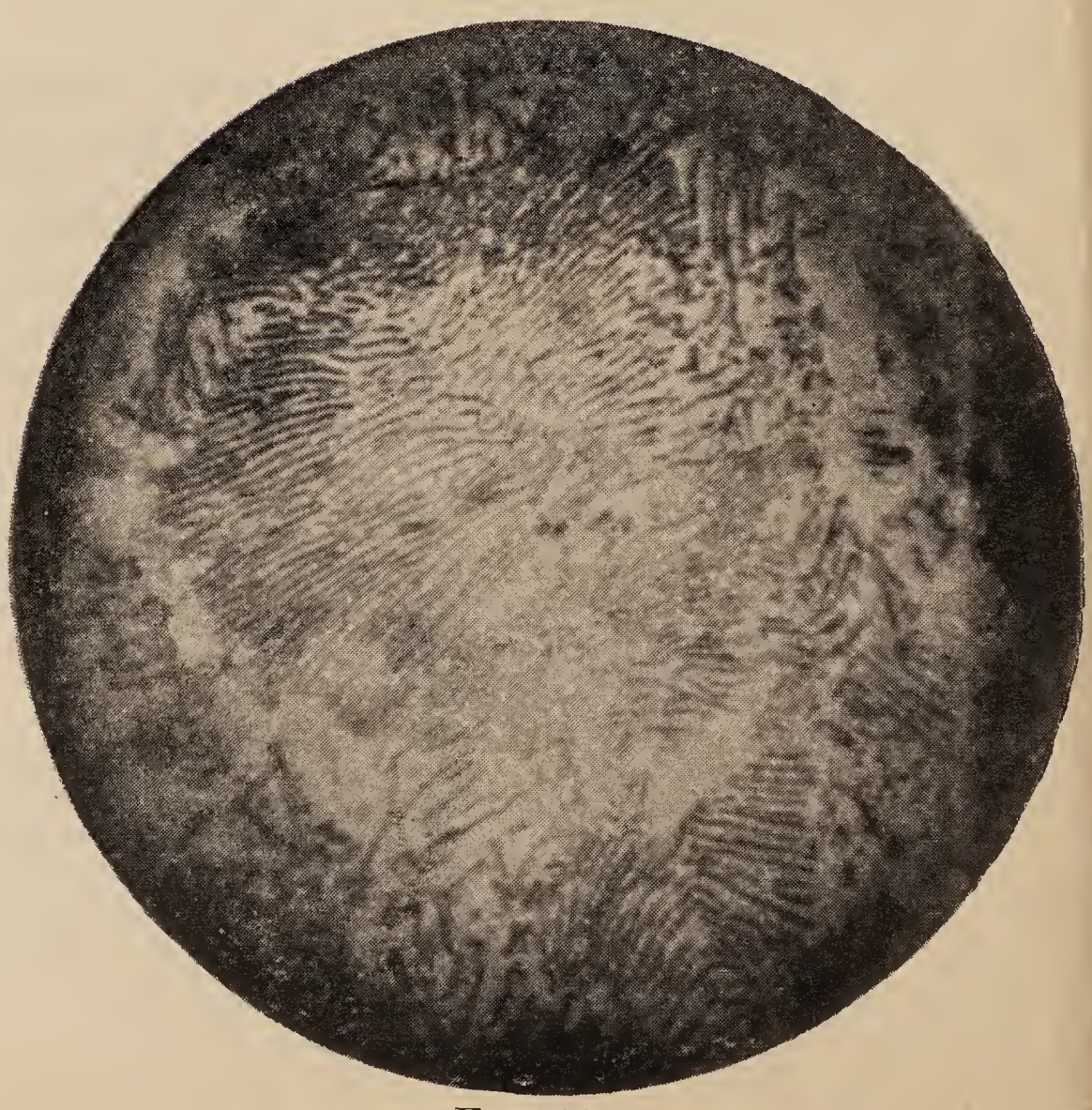
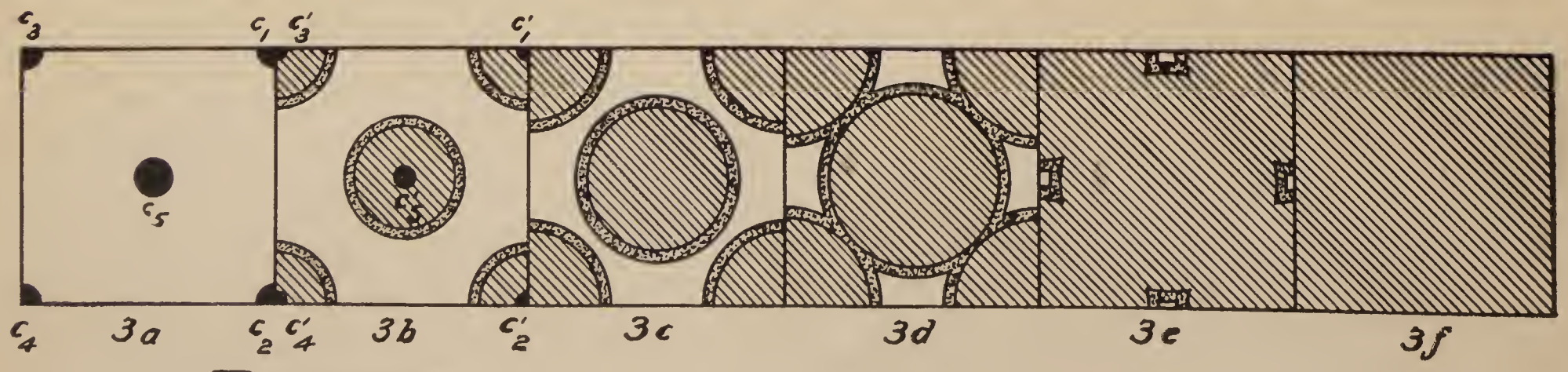


FIG. 294.

ETCHINGS OF STEEL.



DIFFUSION OF CARBON.

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VOL. XII. APRIL, 1896. No. 2.

STRUCTURE IN STEEL.

BY P. H. DUDLEY, C.E.

(*Read February 21st, 1896.*)

The combination of a few hundredths of one per cent. of the metalloid carbon with the metal iron not only changes the structure of the latter, converting it into steel and making it stronger, but gives it entirely new properties. Owing to the ready facility by thermal treatment of so easily modifying the structure of steel, which can be produced in so many grades giving a wide range in physical properties, it has received a greater development in the past thirty-five years than any other metallurgical product.

The term steel is no longer confined to the crucible steels of a few years since, but includes a great range of products from a few points in carbon to those of over two per cent., while there are a number of special steels—some other metal forming a large percentage of the alloy.

The output of steel in this country has increased from 11,838 tons of crucible steel in 1860 to over 5,000,000 tons of all grades the past year, one-fifth the product being steel rails. 9,000,000 tons of pig iron were produced last year, more than one-half of it being converted into steel. Steel has rapidly supplanted iron for the ordinary grades, as it can be produced cheaper and more rapidly than iron, and is much stronger.

The medium and hard steels may be forged, pressed, rolled

and machined into shapes. Then by further thermal treatment, at a temperature far below fusion, a modification of the internal structure of the mineral aggregates is produced, the steel having the wonderful property of acquiring great hardness by rapid cooling, which can be modified by subsequent tempering. These wonderful properties of the carbon steels permit of obtaining a great range of physical properties out of the same bar, by modification of the structure by thermal treatment at different temperatures. While these facts are generally known in regard to tool steels, they are not as generally known as they should be for other grades, and a large portion of steel is used with its mineral aggregates too well developed for the steel to sustain more than one-half or two-thirds of the strain it could were its structure in proper condition.

I have here a small rod of steel one foot long, one end so hard it will scratch glass, the other end being so soft I can cut it with a knife, while intermediate between the ends are many grades of physical properties, the central portion having a structure so fine that it has a probable tensile strength equal to 200,000 lbs. per square inch, nearly double what the untreated end will stand. The hardened steel is so hard it is as fragile as glass. Every inch of the rod has a different structure, the hardened end being the coarsest owing purposely to such a high temperature being used as to fully develop the crystals on the first inch of the bar. The structure decreases in coarseness to the centre, then increases slowly to the untreated end.

The knowledge of being able to harden steel is many centuries old, and has been an important factor in advancing civilization. The iron of the ancients being produced in small quantities by reducing the iron ores in charcoal fires, it would not be necessary to completely decarbonize the product and then recarbonize it again for steel, but they could stop the decarbonization at a point where by further refining the steel they could harden it, which they found out how to do.

There is good reason to believe that steel tools were in use prior to and during the building of the pyramids, for a large

sheet of iron has been obtained from the pyramids of Ghizeh and is now preserved in the British Museum. The famous iron mines of Elba are known to have been worked for over forty centuries, supplying iron to the countries south of the island long before the foundation of Rome. In removing some very ancient rubbish at the mine of Rio Marina a few years ago, stone implements and other objects of the "stone age" were discovered. This seems to show clearly that iron ore was excavated for industrial purposes before the end of the "stone age," and substantiates the assertion that weapons and armor made from Elban iron were used in the siege of Troy, 1280 years B.C. I have used many thousand tons of ore from Elba in the past few years.

The melting of steel in crucibles and casting it was invented by Hurstman, a clockmaker in Sheffield, England, in 1740, about a century after "Dud Dudley" introduced "pit coal" and "sea coal" for smelting iron in England. The past summer I had the pleasure of visiting the scene of his early labors, and from the "Keep" of his castle, which was founded in 700—one of the oldest in England—I saw from his small beginnings, hundreds of stacks sending up their dark columns of smoke or their lurid flames, still reducing ore, coal and limestone from the same mines, the three articles being found in the same locality.

Melting the blister steel and casting it rendered the structure of the steel in a bar more homogeneous than it was possible to obtain without casting.

Since the invention and installation in recent years of the rapid processes for converting iron into steel, grades of low, medium and high carbons are rapidly produced, and a customer can obtain grades which he may consider best suited for his purposes.

In steel for boilers, for bridges and great structures, which must be fashioned and punched cold, the structure must be such that it is homogeneous, soft, and does not sensible harden when suddenly cooled, has great ductility, and suffers great distortion before fracture.

For guns, projectiles, marine shafting and armor plates, a

higher grade of steel must not only be used, but it must be further subjected to heat treatment to put the structure of the mineral aggregates into the best condition for the special purposes for which each steel may be designated.

When crucible steels were the principal output, carbon was considered about the only element it was necessary to add to improve the steel, but since the structure of steel has been studied of late years a number of metals have been found which give special properties to the steel which carbon alone will not do. We now have nickel steels for armor plates, guns and shafting, chromium steels for projectiles, and manganese steels, which have the property of being toughened when red hot and plunged into water—just the opposite to carbon steels.

There are several methods for studying the structure of steels, the most prominent being:

First. The texture of fractured surfaces unhardened, hardened and tempered.

Second. Physical properties.

Third. The changes in appearance of the surfaces under distortion, wear, or physical tests.

Fourth. Chemical analysis of the constituents.

Fifth. Phenomena under heat treatment.

Sixth. Polishing and etching surfaces for examination under the microscope.

Seventh. Photomicrographs of the etched surfaces.

I have named the methods of the list in the order which they have been developed. The first, second and third are the oldest, and served for the development of steel until the present century, and they are still indispensable. The texture shows at once whether the fracture is fine or coarse-grained, fibrous, crystalline, or granular. The grading of fine crucible steels is still made by the texture, and the men are so expert that it is said they can readily grade to within one or two hundredths per cent. of carbon by the eye. You will note from the specimens before you the striking difference in

texture—some very coarse while others are so fine the texture is hardly discernible.

The physical properties of steel may be soft or hard, weak or strong, tough or brittle, each of which can be traced to its respective structure. This must be understood as referring to dates long before the use of the testing machines, which are of recent construction, and refer to properties which would be generally understood but not definitely expressed as a measured property or quantity. The appearance of test bars under severe strain in a modern testing machine at once indicates a fine or coarse texture long before fracture takes place, and conveys quite as much information as to the condition of the metal as the determined elastic limits and ultimate strength. I have here a portion of a tensile specimen which was in excellent condition, the elastic limits being nearly 100,000 lbs. and the ultimate strength nearly 180,000 lbs., which extended perfectly smooth. After fracture in the testing machine one end was doubled upon itself and did not break until it was completely closed. Such material not only has great strength, but can withstand severe shocks.

Chemical Analyses.

All grades of steel are now made up according to some chemical composition. For the low grades which receive a very uniform treatment of manufacture, we can calculate approximately what the ultimate strength will be from the chemical composition, or, in other words, a definite structure is the result for the given composition and treatment. This should be true for the higher grades, but the results have not been so closely determined, and there is a quite general opinion that the relations between the chemical compositions and the physical properties cannot be traced. It is a very complex problem and it will require years to collect the data and solve the question.

Phenomena under Heat Treatment.

As heat treatment is now used to modify the structure of steel as one of the important steps for putting the structure in the best condition, we should be able to see at the temper-

ature when the changes occur the effects upon the steel bar. Some steels after being heated, say to 1000 degrees centigrade, as they cool down after reaching a temperature a little below 750 degrees will suddenly rise in temperature—or at least the rate of cooling for a few seconds will be much retarded—and then proceed with greater rapidity. In some steels with little carbon content, three distinct periods of retardation occur, while in steels higher in carbon but one decided retardation is noted.

Osmond has designated these points—ar_3, ar_2, ar_1, and these points are shown in a diagram (Plate 53) of the cooling down of four steel rails with different percentages of carbon. When the decided change occurs in a steel bar it is usually called the recalescence, and in a steel rail which has a more compact mass of metal in the head than base, the latter cooling sooner than the head, the recalescence of each does not occur at the same time, but a few minutes apart, the base curving around the head and then the head curving around the base and finally as the rail becomes cool it is supposed to cool straight, but practically it does not.

In order, however, for the rails to cool approximately straight after they leave the rolls and are sawed into lengths, some 6½ inches being allowed for shrinkage for a 30-foot rail, the rails must be cambered from 4 to 16 inches, depending upon the relative masses between the heads and base. I have balanced my section so they only require the minimum amount of camber. After the rails are cambered they go to the hot-beds, where in three or five minutes, while the general temperature of the rails is reducing, they straighten, then the base curves around the head nearly as much in the opposite direction as it was cambered in the first place. This is the recalescence of the base. In one to three minutes the rails restraighten—recalescence of the head—then the head continues curving around the base until the camber is much more than the original amount. This takes place in ten to twelve minutes as a rule, then as the rails cool, in twenty-five to forty-five minutes they straighten, or practically so, for the third time. The rails with deep heads are quite irregular, for the

most experienced man cannot always judge as to the correct temperature of each rail and adjust his cambering machine. The illustrations, Plates 54, 55, show the cooling of two different types of rails on the hot-beds. Plate 56 shows the curves of radiation of head and base of cooling rails, indicating also the recalescence.

Polishing and Etching Surfaces and Examinations under the Microscope.

Dr. Sorby of London was, perhaps, the first to take up the study of the structure of steel by preparing their sections, etching them and studying the structure under the microscope. Dr. Marten, of Berlin, has a special laboratory fitted up by the German Government for the preparations of the specimens, etching, microscopical study and making photomicrographs of the etchings. Dr. Welding, of Germany, has also studied the microscopic structure of steel. It is now many years since I took up the study of the structure of steel under the microscope, and designed a type of section which has become the type of sections for many countries. Dr. Howe, of Boston, in writing his work, "Metallurgy of Steel," analyzed Dr. Sorby's work, and in place of the long and cumbersome descriptions given by Dr. Sorby suggested mineralogical ones:

1st. For Sorby's free iron, Howe suggested Ferrite.

2d. For iron combined with carbon, the intensely hard compound, Cementite.

3d. For the pearly constituent or compound re-crystallized, Perlite.

4th. For the pearly constituent or compound un-recrystallized, Hardenite.

5th. For the ruby and dark crystals, Sorbite.

The list could hardly be considered more than a provisional one. A great many investigators, working on different steels prepared at different temperatures, have as yet only recognized three of Dr. Sorby's constituents as probably primary ones of steel. The subject is very diffcult and complex. Osmond of Paris, who has devoted years of labor to the study of the structure of steel for scientific and industrial purposes, using one of Le Chatelier's electric pyrometers to measure

the temperature to which he heated or hardened his steel, gives and describes a provisional list of five probable primary constituents of the carbon steels. He has recently sent me his paper and some of the many photomicrographs he has taken, to study and illustrate the subject. From the extreme difficulty of the work, you will notice that the photomicrographs are excellent, and so far as I know have not yet been equalled. It must not be supposed that it will be possible for the microscope to resolve anywhere near the molecular structure in steel, only that structure which pertains more nearly to the mineral aggregates near their inception and subsequent development, and if a sufficiently high temperature is reached, more or less well developed crystals are formed.

Iron has been considered to have two allotropic conditions for some time. Osmond now speaks of three as well defined, and mentions a fourth. The cementite constituent of steel is the hard carburet of iron mentioned by Caron and described by Sorby, Welding, Marten and Osmond. The martensite is a transition condition and is possibly not a primary constituent. Troostite is also a transition condition in the hardened steels. Sorbite, Osmond considers about the same as pearlite, described by Sorby, which he has named in honor of Dr. Sorby; but in his descriptions of the photomicrographs, he speaks more frequently of perlite than sorbite; therefore some ambiguity exists as to his real meaning, though it is a matter of little consequence, for further studies will clear up these points, and elucidate many more which are doubtful in the larger lists of special steels.

How all the different metals and metalloids are distributed in the complex mineral aggregates of steel has not been determined. All of the metalloids, even in very minute quantities, have an important influence in modifying both the structure of the mineral aggregates and the steel. Unless different observators work upon the same piece of steel, and under the same conditions as to temperatures, their etchings will have marked differences of structure, and will continue to give rise to different interpretations.

Osmond, in order to work out his results, secured four

steels, one of 0.02 in carbon, one of 0.14 in carbon, one of 0.45 in carbon, and one of 1.25 in carbon. Then he used the pyrometer before mentioned, to measure exact temperatures to which each piece of steel was heated, hardened or treated.

Steel of 0.02 in carbon, practically pure iron:—This was specially prepared for this examination. The irregular grains of the ferrite are shown by Fig. 307. Heating the bar to a white heat did not sensibly change the structure. This was only a very small piece and the remark does not apply to large pieces of common iron more or less impure, for in large pieces the structure is often very large.

Steel of 0.14 in carbon:—This is a grade used for many purposes—boilers, structures and bridges. In polishing by bas-relief, a number of scattered filaments, more or less curved, detach themselves and appear dark on the photo-micrograph. These are the fragments of perlite mixed with cementite and sorbite, which reduce themselves to simple lamellæ. Prof. Welding calls this crystalline iron. The surplus is ferrite. By prolonged polishing the polyhedral grains of ferrite appear. The perlite is not clearly distinguished in the large joints.

The Influence of Annealing.

Above 1,000 degrees centigrade the grains become irregular and have a tendency to lengthen in groups of bands in juxtaposition. The perlite is generally on the exterior of the mineral aggregates, and stratifies itself in joints for a steel of this percentage of carbon. The dimensions and forms of the grains are practically characteristic for a given temperature. Figs. 157–159 and 160 represent a common enlargement of 100 diameters, forged and reheated to 750 degrees—shown by Fig. 157, and reheated to 1015 degrees, Fig. 159, and reheated to 1330 degrees, Fig. 160. We see at once the effect of a small percentage of carbon to modify the structure at different temperatures.

Influence of Hardening.

A disc of steel was heated to 960 degrees, a temperature at which the point ac_3 has been passed, cooled slowly to 670 degrees and then hardened in water at 15 degrees temperature.

The polish brings into relief a number of inclusions, but less delineated than in the annealed steels. The inclusions are not perlite, but martensite, with a fine border of troostite. The martensite is formed upon hardening the steel, and is not found before hardening in the ordinary carbon steels. It is not yet certain that it is a primary constituent of carbon steel, but it is at least one of the transition conditions. It perhaps represents one of the crystalline originations under the influence of carbon on one of the allotropic conditions of iron. It will be interesting to see whether it is contained in the self-hardening steels.

Steel of 0.45 in carbon. This grade of steel, heated to 825 degrees and hardened at 720 degrees in a mixture cooled to — 20 degrees, shows structure vaguely by the polishing in bas-relief; but the martensite develops in the polish attack, and then one sees a feeble hollow of groups of needles or rectilinear fibres orientated, parallel or separated, filled up with grain or vermicular markings. Three systems of fibres respectively parallel to the sides of a triangle are frequently seen in the same region.

A 0.45 carbon steel, heated to 825 degrees and hardened at 690 degrees, under polish in bas-relief, shows the nuclei in relief, and the shreds in holes, and between the two a border of great variability and intermediate hardness, and after the polish attack the nuclei are seen to be martensite and the soft shreds are ferrite. Fig. 208. The troostite is also a transition form in hardened steel.

Steel of 1.25 in carbon. A steel of this grade, annealed to 750 degrees, is nearly formed of perlite. The alternate lamellæ appear very definite at some points which Osmond has named sorbite in honor of Dr. Sorby; but, as I have stated, he still retains the use of perlite in his descriptions.

Perlite, Fig. 249, is from this grade of steel—1.25 in carbon. After annealing, the hard lemellæ are the perlite and cementite, and the soft lamellæ ferrite. Osmond says, "the facts show that the alternate lamellæ of the perlite can be formed sometimes of sorbite and ferrite, and sometimes of cementite and ferrite, with or without the intervention of

sorbite. The chemical composition of sorbite is yet unsolved, but it is possibly a variety of the hardening carbon." In a science which is so new it must be expected that some doubt and confusion exist which will become plain as progress is made. Already it is possible from a given piece of steel to very definitely trace the last thermal treament it has received, and to further note whether or not any previous thermal treatment has been injurious to the steel.

Osmond's schematic diagram of the diffusion of carbon by heating the steel is very interesting and instructive. He assumes for illustration that the carbon of the mineral aggregates is concentrated at their centres surrounded by ferrite. He takes a square of ferrite and in the centre places a disc of carburet of iron FE_3C, cementite and sorbite. He also places a portion in each of the four corners of the square —represented by 3a. Then he elevates the temperature, and at the point ac_1 the cementite decomposes itself and emits an atmosphere of carbon under the form of hardening carbon. Whatever may be the exact chemical signification of this word, the carbon diffuses itself as though it were a gas under pressure, and up to the end of the transformation of the temperature of ac_1 the situation will be represented by the scheme 3b. The black circles of cementite are reduced and surrounded by a zone of martensite, shown by hatched lines, which are bordered by a narrow zone of troostite, shown by a zone of dots. [Plate 57.]

In a temperature a little higher the cementite disappears, 3c, and the martensite increases. If the temperature increases the martensite circles expand and the troostite zones of transition become fused, 3d, the martensite still further coalesces as in 3e, and finally the entire portion of the ferrite is affected as in 3f. This progressive diffusion of the carbon takes place in a variable temperature and also requires an interval of time. In the slow cooling down of the steel the phenomena above described would reverse. Osmond describes a zone of transition sorbite between the cementite and the martensite, but does not show it in the schematic diagrams.

The query is raised in one's mind, in what state or condition

is it possible for carbon to exist in steel, by which, between temperatures of 650 to 850 degrees, it is possible to make it so completely diffuse itself through the mass of iron, that it can be held in that state of diffusion by rapidly cooling the metal?

I have previously shown you a small ingot of 0.48 carbon steel, where I had placed a solid battery carbon on one side of the mould, and when the hot steel was poured into the mould, this side, for the first $\frac{1}{16}$ of an inch, absorbed 1 per cent. of carbon, and the carbon increased beyond the third sixteenth of an inch in depth. The ingot was small—about 8 pounds—and only remained hot a few moments. This was similar to the method of Harveyizing armor plates, which are embedded on one side in wood or bone charcoal in large furnaces, and a red heat is maintained in the plates for 12 to 15 days. One side absorbs an additional quantity of carbon, and when it is sprayed with ice-cold water, the face of the plate becomes so hard that it cannot be scratched with a steel tool. This hard surface is for the purpose of breaking up the projectiles of hostile guns. At Schneider & Co.'s Armor Plate and Gun Works, Cruesot, France, they are putting in a large heating furnace, two armor plates with a gas-tight space between them. The plates are heated red hot and the space charged with a carbonaceous gas, the plates absorbing the carbon. Solid carbon does not come in contact with the plates, the structure being modified with gaseous carbon.

So far as we can now resolve, the structure in steel under the microscope with a power of a thousand diameters, as before stated, there seems much beyond our power, while beyond this is the molecular structure. Elasticians who must work out the formulæ for the deflections of beams, etc., from the laws of the elasticity of metals, assume a mathematical form of structure of the mineral aggregates of far greater homogeneity of structure than exists, and their formulæ do not apply beyond the elastic limits of metal, which may be nearly the ultimate strength of the metal, or not more than five or six tenths of the amount.

In the first place we have metals which are brittle or may

be fragile, while in nearly all work we need a structure which gives not only high elastic limits, but also has sufficient ductility to take up an excessive strain without fracture. Particularly is this required in guns, armor plate, marine shafting and rails. The safety of rails largely depends upon the properties stated.

The rapid increase in work to which metals are now subjected requires a higher grade of steel, a better and finer structure than was required a few years ago. Think of steam boilers now carrying 180 to 200 pounds pressure per square inch; a marine shaft which must stand the stress of 30,000 horse-power for six or seven days, and which it is expected it will do for many years. We read of too many failures, and not until higher grades of steel are used and then put into the best possible condition of structure will the failures be lessened. Think of an armor plate resisting the impact of a projectile having 25,000 foot tons of energy, and also think of the structure of steel in the point of a projectile which can deliver that energy to an armor plate and scarcely dull the lustre of its point. Of course, many break. The effort of every nation now is to obtain a structure in its armor plates which will break up the projectiles before or after slight penetration. Only five years ago the theory was to have a metal which was ductile and would absorb the energy of the projectile by making the metal flow around the shell without cracking the plate. To-day a face of hardened steel is considered better, so it will be more apt to break up the projectile.

The high power guns of to-day are built up from thin tubes and hoops which can be treated, putting the steel into the best condition of structure possible for the work it must do. The hoops are heated only to a temperature which will not disturb their structure and then shrunk on to the central tube. A second and then a third hoop is shrunken on to form the breech, which must first stand the stress of the explosive.

Another class of high power ordinance is the segmental wire-wound guns. In each class of guns the structure of the steel has been put in a better condition for the work than it is possible to secure in a single piece of steel of a size sufficient for

a gun of large calibre. Think of the enormous expenditure each nation is making to protect itself from the possible projectiles of 25,000 tons of energy from the guns of some other nation, the principal reliance being in a steel of greater resisting structure than the armor of the attacking party. The activity of each of the great armor-making plants of the world in trying to produce a higher grade than has been produced can hardly be realized until one visits them.

As large as the 25,000 tons energy in a modern projectile is, and the thick and high grade armor it would take to resist it, the amount of energy is not as large as that stored up in many of the fast and heavy trains of to-day, which must be taken up and harmlessly absorbed in a few hundred feet by the structure in a very thin layer of the top of our steel rails.

The structure in a steel rail owing to the changes in temperature is practically always in motion, beside the motion of the molecules in absorbing the stresses in the rails due to the motion of the trains. Take the line from New York to Albany, 143 miles, and suppose we could anchor the rails at Grand Central Station, and that they could move down from Albany under a fall of one degree Fahr., the molecules would all be put in motion and crowded together, leaving a gap in the rails at Albany of five feet opening. Of course, a drawing of the rails for the entire distance could not be tolerated, but the fall in temperature of one degree puts a tension of 200 pounds in the rails which are held at each end. The fall in temperature in the recent cold snap of 100 degrees in a few days put many of the rails under a tension of 20,000 pounds, for it requires a greater force than 20,000 pounds to slide the rails in the splice bars. As the temperature rises the tension is released, and in summer the rails would be in compression. It is the severe tension on the rails which is largely the culminating cause which breaks so many rails in cold weather, rather than the great decrease in ductility in the metal. There is no other form of steel subjected to so many stresses as that of steel rails, and it is a matter of necessity for safety and economy to have good structure in the steel.

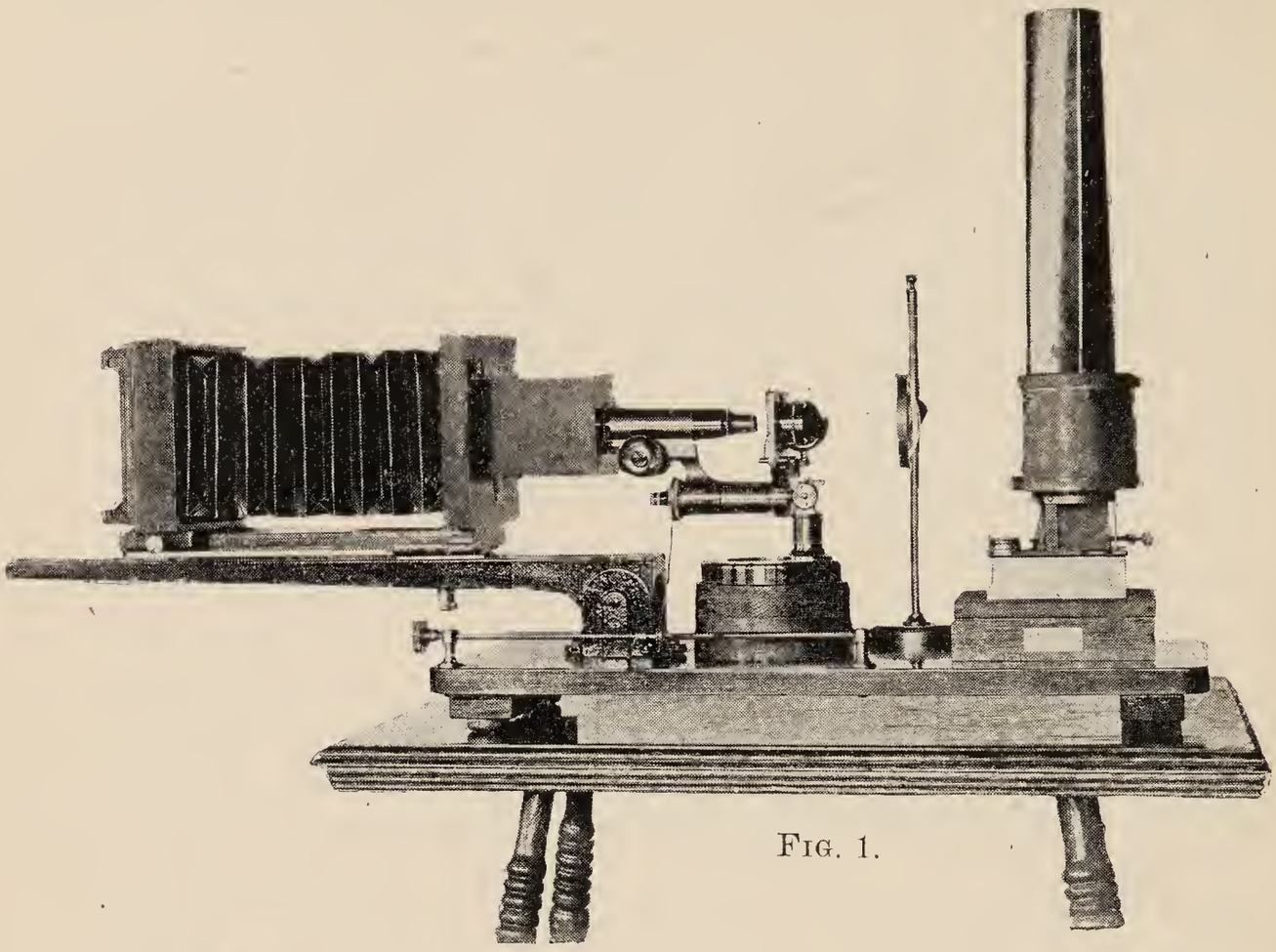

FIG. 1.

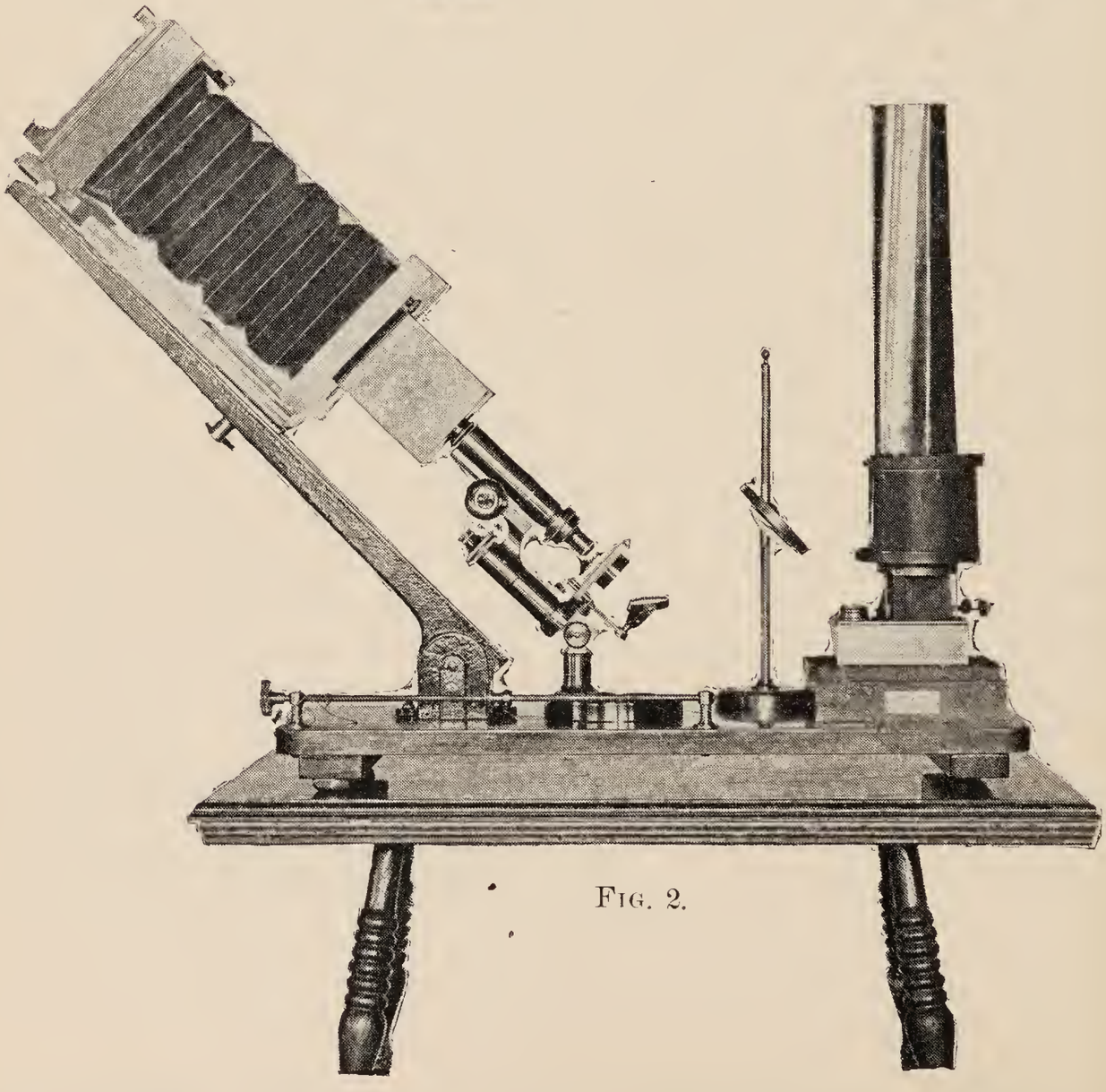

FIG. 2.

WALMSLEY, FULLER & CO.'S AUTOGRAPH CAMERA.

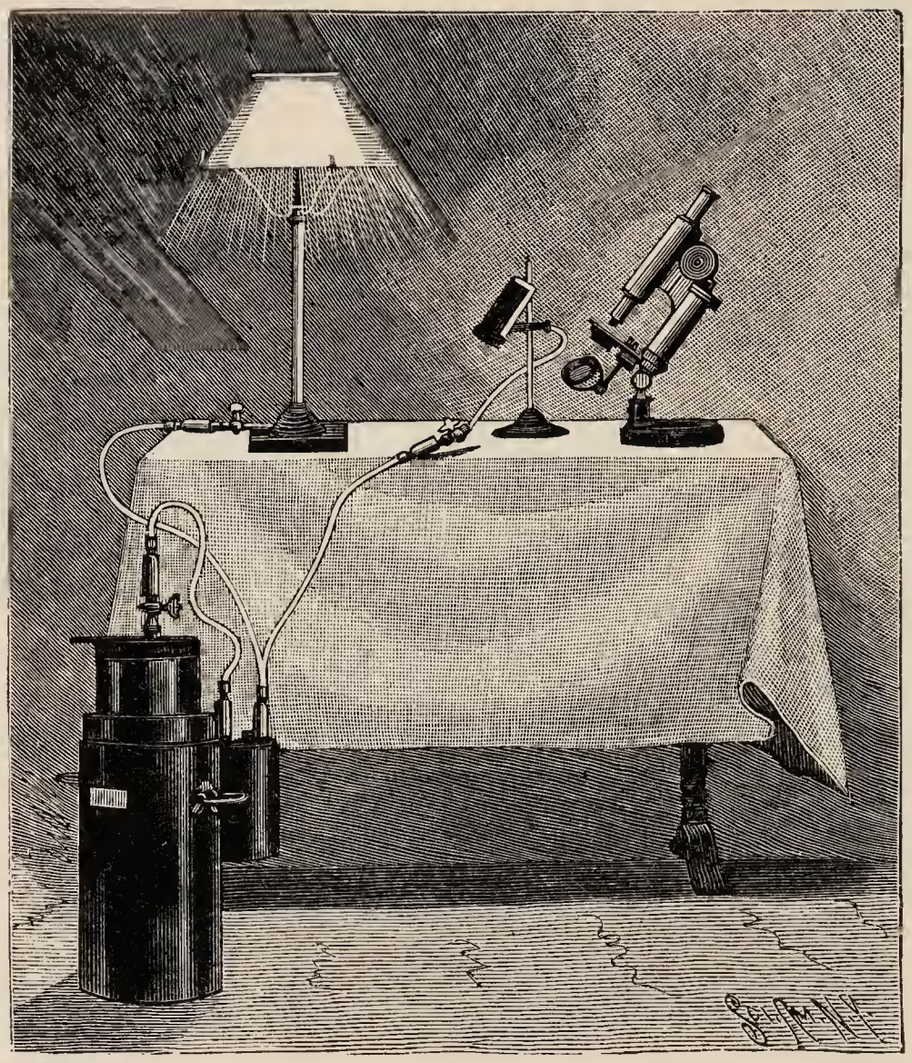

FIG. 1.

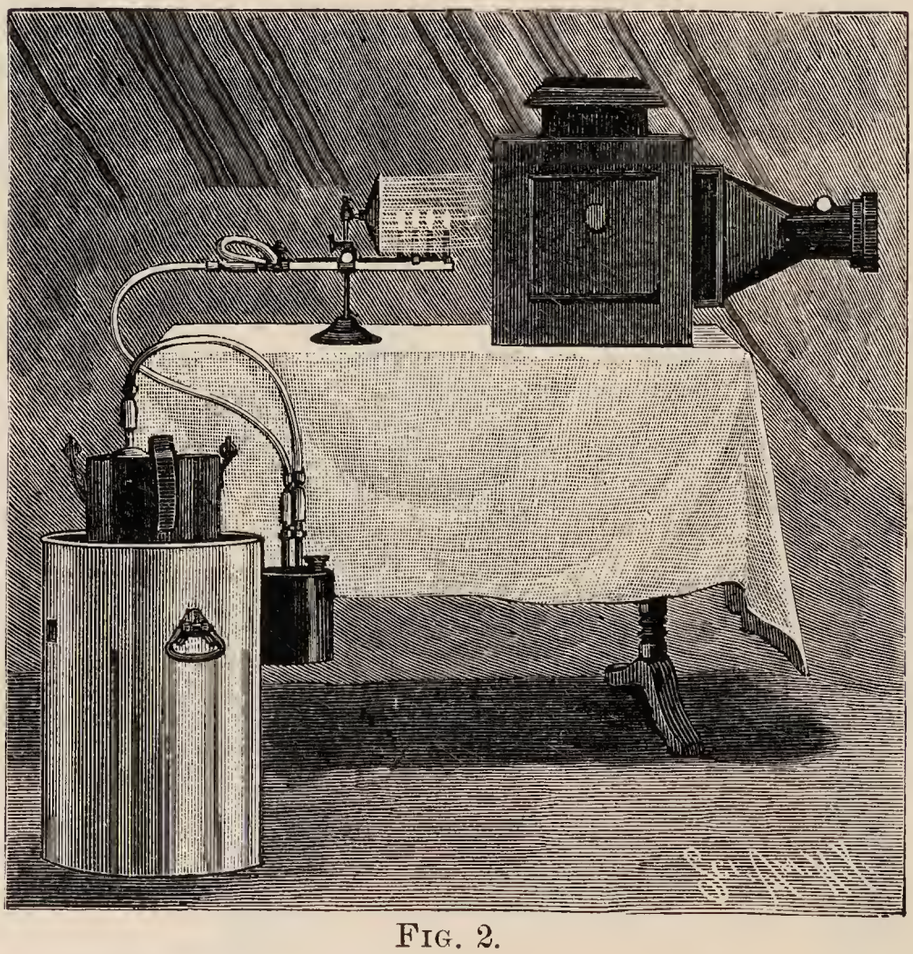

FIG. 2.

WALMSLEY, FULLER & CO.'S ACETYLENE GENERATOR.

WALMSLEY'S "AUTOGRAPH" CAMERA, AND WALMSLEY, FULLER & COMPANY'S ACETYLENE GAS GENERATOR.

BY CHARLES F. COX.

(*Abstract of an Address delivered February 7th, 1896.*)

Walmsley's "Autograph" Camera possesses many advantages with regard to compactness, steadiness and general accuracy. It differs from the usual form of upright camera in respect to being applicable, not only to photographing objects through the microscope, but also to the copying of photographs and pictorial illustrations either enlarged or diminished in size, and to the making of lantern slides by the camera process. For these last mentioned purposes there is provided a metallic support inclined at an angle of 45° to be placed upon the baseboard, and to which the photograph, engraving or negative can be attached, although, for the purpose of copying a transparency or negative it may be found convenient to make use of the form of printing-frame which is provided with a wire support, and from which when in use in this manner the wooden back has been removed. In any case, when printing from a negative a proper illumination is to be had by laying a sheet of white paper upon the baseboard behind the supporting frame and adjusting it with reference to the source of light so that it will act as a reflector. When thus employed, the camera, which is supported by an iron arm hinged near its base, is to be tipped at an angle of 45° from the perpendicular, at which point it can be fixed by the insertion of a pin in a hole through the two sections of the iron support. For ordinary work with the microscope the camera will, of course, be used in a horizontal position, but the perpendicular position is also available in case it is desired to photograph an object in liquid or to adapt the camera to the Continental form of microscope, not having a joint in the body. In any of its positions the camera has been found to be steady enough for all practical purposes, although at first sight the plan of supporting it upon a single arm might seem to be mechanically

defective. It would be an additional convenience if the apparatus were provided with a second board on top of the baseboard and pivoted to it at the end nearest to the camera, upon which the microscope and illuminating apparatus should stand, and by means of which the microscope could be turned at right angles to the axis of the camera for purposes of adjustment and focusing. This will be the preferable arrangement when the microscope to be used is rather low upon its stand, and will not thus be raised too high for the opening in the front of the camera. When using the camera with a relatively high stand, it may be well to fix the supporting arm to a revolving disc of wood, so that instead of moving the microscope the camera itself can be turned to one side, and by way of counterpoise to attach a weight of iron or lead to the underside of the baseboard and near to the opposite edge. It is probable that this modification can be made without in any way disturbing the general steadiness of the apparatus. As the "Autograph" Camera is capable of being used for all of the purposes for which Mr. Walmsley's former micrographic copying and enlarging camera was designed, it will be found more convenient to workers who cannot afford the space which the larger form required for its use and storage, and it will be welcomed as a successful solution of a difficulty which is often experienced because of a lack of laboratory facilities and the necessity for doing microscopical work in a general living room. The camera exhibited is adapted to a 4 x 5 plate, but Mr. Walmsley has also designed, and is probably ready to supply, several larger sizes, although the advantages of compactness may be sacrificed by adapting the camera to a plate larger than 5 x 7. Of course, any form of illumination is practicable with the camera exhibited, but one of the very best is the acetylene gas lamp, about to be described.

Mr. Cox then set up and exhibited in operation Walmsley, Fuller & Company's No. 2 Acetylene Gas Generator, and wrote upon the blackboard the chemical formula for the reaction taking place, as follows:

CaC_2	+	$2H_2O$	=	$Ca(HO)_2$	+	C_2H_2
Cal. Carbide		Water		Cal. Hydrate		Acetylene

Calcium carbide is produced by the fusion in an electric furnace of coal or coke dust and lime in the proportion of about 1,150 pounds of the former to about 1,750 pounds of the latter, the result being a ton (2,000 lbs.) of the carbide. Each pound of carbide as now supplied is capable of generating about 5 cubic feet of acetylene, though it has been claimed that with an absolutely pure carbide as much as 6⅓ cubic feet have been obtained. Walmsley's portable apparatus is a modification of the old-time hydrogen-gas generator, consisting in this case of an outer vessel of metal holding water, and an inner vessel open at the bottom and sliding into the outer one, containing a wire screen or basket to hold the carbide, and having at its top a stop-cock through which the gas passes off as generated, and to which a tube is attached for the purpose of conducting the gas to the burner. To set the machine in operation it is necessary merely to place the carbide upon the wire screen within the gasometer, and to sink this into the water, whereupon the evolution of gas begins at once, the breaking down of the carbide being similar in its operation to the slacking of quicklime. The stop-cock being left open, the contained air is quickly expelled, and as soon as the gas begins to flow, which may be known by its peculiar garlic-like odor, the rubber tube is at once attached to the projecting nipple. In the chemical reaction which takes place a considerable degree of heat is set free, as in the slacking of lime, and the gas comes off warm and loaded with a large amount of moisture. It is found desirable before leading it to the burner to both cool and dry it. It is therefore passed through a small chamber, consisting of one metal cylinder within another, the space between the two being filled with cold water, the gas traversing the central cavity, in which are placed several wire screens or fans, through which it is obliged to take an irregular course, so that when it emerges from the chamber it has imparted some of its heat to the water and deposited some of its moisture upon the wire screens. It is then conducted by another tube directly to the lamp.

Acetylene cannot be used with a large burner without pro-

ducing smoke. The maximum size with the larger forms of this apparatus is a one-foot burner, while with the smaller sizes, in which the pressure is relatively light, a half-foot burner is found the most effective for purposes to which the fish-tail flame is applicable, as, for example, in projection with the lantern. For this purpose a combination lamp, consisting of two, three, four or more half-foot burners, is provided by the makers of the apparatus, but, of course, they can be used for a considerable length of time only in conjunction with the larger sizes of generators, of which Walmsley, Fuller & Co. make several patterns, graduated to a charge of ¼ lb., 1 lb., 2 lbs. and 5 lbs., respectively, No. 2 being the 1 lb. size. They claim for each half-foot burner, under a maximum pressure, a power of from 100 to 125 standard candles, but this estimate is probably much too high. As each burner consumes one-half cubic foot of gas per hour, four such burners should take two hours and a half to consume the amount of gas generated by one pound of calcium carbide, but it has been found practically impossible to run a lantern with four such burners for two hours with the amount of gas stated, probably because of the poor quality of the carbide at present obtainable, and also, perhaps, because of the under-rating of the so-called half-foot burners. In fact, one of the chief difficulties with the use of acetylene is the impossibility at present of finding a burner exactly suited to its peculiar requirements. Experiments made in Boston seem to establish the fact that a consumption of acetylene at the rate of five cubic feet per hour will give 200 candle-power, as against 25 candle-power from five feet of ordinary illuminating gas; in other words, taking them bulk for bulk, acetylene is capable of producing eight times the light of carbureted hydrogen. On this basis a thousand cubic feet of acetylene, at a cost of $10, will give as much light as eight thousand cubic feet of carbureted hydrogen, at a cost of, say, $1.25 per thousand; so that at the rate of $100 per ton for calcium carbide the cost per candle-power would be the same for the two illuminants. It is generally conceded that, even in small quantities and under unfavorable

conditions, the carbide can at present be produced profitably at $100 per ton, and, perhaps, considerably less. But the carbide here employed has been purchased at retail at a cost of 50 cents per pound, or at the rate of $1,000 per ton. Its price, however, is mainly dependent upon the cost of the electrical current used in the reduction of the coal and lime, and trustworthy calculations have been made which indicate that with electrical power favorably located, as, for example, at Niagara Falls, the carbide can be manufactured at a cost close to $20 per ton. Taking into consideration the immense quantities of refuse coal-dust piled up in the neighborhood of every coal mine, it is easy to believe that if limestone and efficient water-power could be found in the same locality with the coal, this ideal combination of circumstances might result in reducing the cost of carbide to possibly $10 per ton or less, and those most hopeful with regard to the future of acetylene have predicted some such ultimate outcome.

Our interest in acetylene, however, is not centred upon its commercial importance, but on its practical utility as an illuminant, and in this regard it has several decided advantages over water-gas or coal-gas. In the first place, the light is so pure and white that it is agreeable to the eye, and favorable to the exhibition of colored objects, while, because of its perfect combustion, the flame is devoid of the purple centre usually seen in gas flames. Secondly, it is highly actinic, and therefore very effective in photography, reducing the time of exposure considerably, in comparison with coal-gas or oil. Compared as to candle-power, the acetylene flame has two and one-half times the actinic power of the common illuminating gas. Thirdly, the temperature of the acetylene flame is much lower than that of carbureted hydrogen, and it imparts much less heat to the atmosphere in which it is burned. The heat given out by acetylene is said to be only one-third of that given out by water or coal-gas, although it is more than that produced by the incandescent electric light. The maximum temperature in the acetylene flame is less than 1000° Cent., while in the flame of coal-gas it is said to be nearly 1400° Cent. Fourthly, the amount of carbon dioxide resulting from

the consumption of acetylene is reported to be only one-sixth as much as that produced by coal-gas, on the basis of candle power to candle power; so that, with equal illumination we can burn acetylene for six hours with only the same vitiation of the atmosphere as we get from one hour's use of the other gas.

For employment with the microscope, Walmsley, Fuller & Co. furnish a very efficient little lamp, consisting of a pin-hole burner surrounded by a metal tube an inch in diameter and three inches high, lined with plaster of paris, and having an ordinary 3 x 1 glass slip run into a slot on one side, the whole being supported upon an adjustable stand, so as to vary the height of the lamp and also its position with reference to the perpendicular. The flame is narrow and long, but at the full pressure is bright enough for every possible purpose. It consumes an exceedingly small amount of gas, and may be run for several evenings with the No. 2 Generator now shown, and would probably work very well with a still smaller gasometer. It is certainly superior in its effects to any other gas or oil light, and even in some respects to the usual incandescent electric light, by the side of which trial has been made of it with the microscope. It seems to be the best illuminant available at present for photomicrography, and a strong recommendation may be accorded to the compound lamp intended for the lantern, which is likely to take the place of both electricity and the oxy-hydrogen light for use in a small room.

The present form of generator is somewhat inconvenient on account of the necessity for cleaning it out and re-charging it at frequent intervals, but it is hoped that before long some method will be devised for running the apparatus continuously if needed. With the No. 3 and larger forms it is already possible to manufacture enough gas from one charge to run a small lamp for a long time, and to shut off the flow and preserve the supply for several successive days, since the pressure of gas in the receiver will automatically raise the carbide out of the water and keep matters in *statu quo* with practically no danger of leakage. Like most other new applications of scientific principles, the employment of acetylene has been invested with a great deal of unnecessary mystery,

and particular emphasis has been in certain quarters laid upon the dangers attending its use. But nearly all the warnings put forth in the newspapers are applicable only to the employment of acetylene condensed to the liquid form in steel cylinders under enormous pressures. Used in any ordinary way, it is doubtful if the new gas is any more dangerous than the common illuminating gas. Certainly whatever risks there are about it are reduced to an absolute minimum in the simple apparatus here exhibited.

THE PYGIDIUM OF THE COMMON FLEA.

BY DR. ALFRED C. STOKES.

This organ has been studied so frequently, and by so many microscopists; it has been used for so many years as a test of certain qualities in objectives, that further notes on the subject might be deemed superfluous; it might well be thought that the last word must have been spoken about a matter so common, not to say so hackneyed. It is because the pygidium has been so frequently examined that I cannot divest myself of the belief that the structural features which I have recently observed must have been repeatedly seen by microscopists, although these morphological points seem to be actually undescribed. I can find no reference to them in the literature of the subject which I have been able to examine, yet they are so prominent and so conspicuous that it is difficult to imagine how they could have been so long overlooked, if they have been, especially after such accomplished microscopical observers as Van Heurck, Dallinger, Nelson, Carpenter, have used the pygidium as a test. But some of these investigators, notably Dallinger and Nelson, have lately described previously unobserved features, or features which have previously been misinterpreted.

Mr. E. M. Nelson was the first to describe correctly the form of the so-called spines or hairs which clothe the interareolar surface, calling them lambent, meaning that they are

flame-shaped, thus using the word out of its proper signification, for "lambent" means, not flame-shaped, as the eminent British microscopist intends to suggest, but something quite different. Other observers had noted these spines, and indeed had figured them as stout, tapering bodies arising from a circumvallate depression, to the base of which each was said to be attached by a socket-joint. The fact is that no such socket-joint, nor any structure resembling it, is present on the inter-areolar surface of the pygidium. "As an example of erroneous interpretation," says Dallinger in his edition of "Carpenter," "the representation of the pygidium of a flea by some leading sources of information of a few years ago may be instanced. It was a special test of many authors, and has been carefully figured; this shows that it was not an accidental error, which it might have been if it were merely an ordinary object; it is an error depending in all probability on a faulty system of illumination. Moreover, the error cannot be attributed to the object-glasses of the time, as it is a low-power object, and the low powers of that day were quite as good as those lately in use. In the descriptions and in the drawings, often beautifully executed, the hairs proceeding from the center of the wheel-like discs are represented as being 'stiff and longish bristles,' thick at one end and tapering off to a point. And the small hairs round (*sic*) are described as 'minute spines'; in the drawing they are like the spinous hairs of an insect and have the usual socket-joint at the base. In reality the 'stiff and longish bristle' is an extremely long and delicate filament, totally unlike a bristle, being not tapered but of nearly uniform thickness. The 'minute spines' are in reality very curious hairs, and, as far as we at present know, unlike any others. They are delicate, lambent, bulbous hairs."

These "stiff and longish bristles" which issue from the areolæ appear to be fragile, and are as a consequence readily broken, when they are observable on the preparation as stout, truncated filaments, usually with no trace of decreasing diameter. But when they are unbroken they certainly do taper, and do so conspicuously, at least with the specimens which I

have seen. If a true bristle must taper, then are these true bristles.

The flame-shaped hairs are narrowed with a regular gradation from the somewhat bulbous base to the usually curved and acuminate tip. But if the classical socket-joint of these inter-areolar hairs can be proved to be an error of observation, as can be easily done, then it is not unlikely that there are other structural points about the organ which may have been overlooked or misinterpreted. In fact there seem to be several.

Of some of those to be mentioned here there is absolutely no doubt; of a single one there must be doubtful acceptance until the microtome can be brought to bear on the pygidium, when the problem may be readily solved. I have not even the skill of a novice in the use of the microtome, and those of my friends and correspondents who have attempted to section the pygidium have failed, either on account of the horny character of the subject, or because of the lack of sufficient material. When sectioned it will not be what Dr. Dallinger calls a low-power object; even in its totality it is far from being that.

The areolæ, or those superficially wheel-like bodies which, in number from thirty-two to thirty-eight (Van Heurck) constitute the double, somewhat reniform organ called the pygidium, are not the simple bodies which they are usually supposed to be. The ordinary statement of the books is, as Dr. Van Heurck puts it in the fourth edition of his work on "The Microscope," that, "The pygidium of the flea is composed of two lobes and exhibits from thirty-two to thirty-eight long, stiff hairs emplanted in the center of each of the areolæ, each one being surrounded by a row of little cuneiform elevations. The inter-areolar spaces are covered with small spines. A good objective should show these areolæ clearly defined in all their parts, and the elevations should appear cuneiform, and not round as they are figured by Dujardin." This is not all of the structure as I see it with the best objectives of Reichert, Zeiss and of Spencer.

Each areola is in reality a follicular depression, varying in

dimensions to a degree .perceptible even without the use of the micrometer, but averaging, perhaps, about 1/3000 inch in depth; and each contains not only the long central, bristle-like filament and the cuneiform projections, which are said to form a single row, but a somewhat complex, strongly chitinous system of rods and wedges and membranes, the whole apparatus being covered by an elevated, membranous dome about as high above the general surface as the follicle is deep below it, and with a central eye through which the long bristle projects, the dome itself bearing some minute external appendages. The areolæ are by no means the simple, uncomplicated objects they are commonly described and figured to be. They have been looked upon by microscopists as low-power objects, as Dr. Dallinger describes them, but they will prove themselves worthy of study with the highest-power objectives at our disposal The structure of these wonderful bodies as I see it, is shown by the diagram accompanying this note.

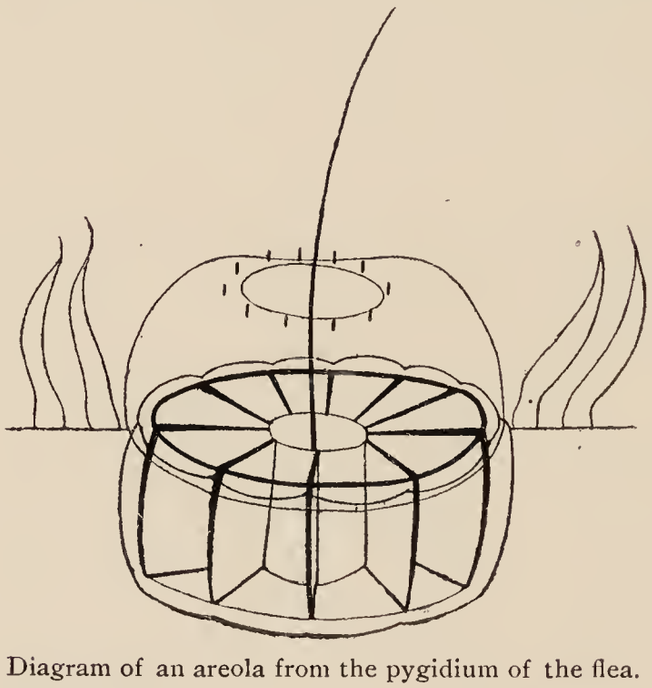

Diagram of an areola from the pygidium of the flea.

The walls of each follicle are vertically fluted at regular intervals, and the upper margin is, as a result, broadly crenated. The cuneiform projections (they are not elevations as commonly described), converge toward the center from a comparatively wide band of encircling chitin, and each is outwardly continued toward the bottom of the follicle by a curved, rod-like body which at the base becomes continuous with a second

set of wedge-shaped projections, often less strongly chitinous than the upper row and always rather shorter. There is not a single row of these cuneiform projections which have so long been used as a test for definition, and which Dr. Van Heurck says Dujardin figures as being round. There are two rows entirely distinct from each other, but connected exteriorly by the vertical rods referred to, and shown in the diagram. At the outer surface of these vertical rods, that is, between them and the internal wall of the follicle, is a delicate membrane which constitutes the outer boundary of the complicated apparatus, and is continuous with the membrane which forms both the upper and the lower surfaces, and fills the spaces between the wedge.shaped projections. This produces a circular chamber strengthened outwardly by the vertical rods, and above and below by the cuneiform projections. If there were nothing more to the intra-follicular apparatus this chamber would be a simple, circular passage open at the center through which the long bristle passes. But the circular region is not open toward the center; it is there closed by a slightly inclined membrane, which extends from the tips of the upper wedges obliquely outward to the tips of the shorter lower projections. This membrane closes the circular chamber, and produces a more or less conical space at the center of the follicle, through which the long filament issues. But whether or not it completes the structure of this part is doubtful. I think it does not. But to become positively assured as to that, a study of sections is necessary, and here the expert microtompist will find a subject worthy of his steel. And here, too, he will meet with an object that will tax his skill in the illumination of the microscope, and his ability to manipulate the best high-power objectives. For this is not a low-power object.

But while I am unable to prove to others that my opinion is correct, still that opinion is that this circular chamber is divided, by vertical membranes, into as many cells or compartments as there are wedge-shaped projections in each row, a membrane extending from a cuneiform body above to the one directly below. I am making no positive statement about

this minute structure, and it is minute enough to be a delightful task for the lover of the delectable instrument; I am expressing only an unproved opinion, leaving to the microtomist the pleasure of deciding the question, and, I am free to confess, envying him the skill needed in the delightful work. However, if these vertical membranes exist, and judging from certain optical appearances, I think they do exist, then is the pygidium of the despised parasite one of the most remarkable structures with which the microscopist can become acquainted.

But perhaps the most pleasing structure, which is also one of those surprising things in Nature, is the delicate dome which arches above each follicle with its enclosed apparatus, and through whose central eye the long tapering filament projects. If this domoid membrane has not previously been observed, I am at a loss to account for the oversight. It is almost conspicuous; it demands only a slightly upward focus to define its rotundity and its circular eye; if the long bristle is followed from tip to base, the dome can scarcely fail to make itself seen.

This overarching membrane is set down above the follicle, and is a little greater than it in diameter, the greatest width of the dome being about 1/1,800 inch with about 1/2,000 inch to that of the depression which it covers. In the diagram it is shown as it appears in surface view, with a regularly spherical outline, the summit somewhat flattened and the region about the central eye conspicuously depressed. In some specimens, probably in all, when seen in profile the dome is widened above, and the convex walls slope inward to the base. But as to the existence of the demoid membrane, there is not the slightest doubt. It is present above every pygidial areola, adding much to the interest of the organ, somewhat to its complexity, and happily adding emphasis to the general belief that the pygidium is an auditory organ. The function of this membranous dome can be readily inferred.

It possesses, however, some minute appendages whose function is not so easily conjectured. Around the eye of the dome, as shown in the diagram, is a single row of from eight to ten projections which, for want of a better name, may be called setæ. These are positively not the tips of the flame-

shaped hairs, and they are as positively not minute folds in the membrane of the dome, but strictly independent organs, minute enough to satisfy the most exacting microscopist who likes to work with high powers. In *estimated* length they vary from 1/15,000 to 1/20,000 inch. I have no micrometer ruled fine enough to measure such setæ, but the estimate seems to be at least within the actuality.

These small objects arise from the surface of the dome in a regular row, and take varying positions, being sometimes perpendicular at the edge of the eye, at times leaning over the margin; in other instances they appear further down the slope, standing upright or variously inclined or curved. They convey the idea of solidity and of firmness, having nothing of the aspect of a bristle, for they seem not to taper, but to be minute cylinders, each apparently arising abruptly from its base, and having a truncated summit. These appearances, however, may be illusory, as the setæ are so exceediagly minute that it is difficult to decide positively. But as a test for definition, the reader will find the little appendages entirely satisfactory. He may perhaps think that the resolving power of the objective should likewise not be slight, and I should be disposed to agree with him.

All this structure, which the reader must admit to be sufficiently complex, is visible within and above the pygidial areolæ of all the common species of *Pulex* which I have examined, but it seems to be rather larger and more conspicuous within those of *Pulex irritans*, especially with those specimens which are to be had in California, where, in addition to big trees and some other large things, our microscopical friends are so fortunate as to have big fleas.

We have received the Transactions of the Eighteenth Annual Meeting (1895) of the American Microscopical Society, held at Cornell University, Ithaca, N. Y. in August last. These Transactions form a fine volume of 381 pages, filled with valuable and interesting matter, and beautifully illustrated. The next Annual Meeting of the Socieiy will be held in the new Carnegie Library Building, Pittsburg, Pa., on August 18, 19, 20 and 21, 1896.

PROCEEDINGS.

Meeting of December 6th, 1895.

The President, Dr. Edw. G. Love, in the chair.

Sixteen persons present.

The following persons were appointed Committee on Annual Exhibition: George W. Kosmak, George H. Blake, William B. Tuthill.

The following persons were appointed Committee on Nomination of Officers: Walter H. Mead, William G. De Witt, F. W. Devoe.

OBJECTS EXHIBITED.

1. *Distoma hepaticum*, Liver Fluke, entire specimen: by E. G. Love.

2. Trans. sect. of do.: by E. G. Love.

3. Photomicrographs of do.: by E. G. Love.

4. Section of Barbadoes Earth containing diatoms: by James Walker.

5. Section of Richmond Earth, containing diatoms: by James Walker.

6. Cow hair from centre of "Bezoar stone": by J. L. Zabriskie.

7. "Bezoar Stone," sawed through to show centre: by J. L. Zabriskie.

8. Specimens of apparatus: by Carl Reichert, of Vienna.

Six Reichert microscopes with various accessories. Numerous objectives. Photographic camera. Polariscope for sugar testing. Sledge microtome. Rocking microtome. Hand microtome. Two spectroscopic eye-pieces. Two camera lucidas (one with diaphragm). Stage micrometer. Micrometer ocular. Lancet for hæmometer. Dissecting microscope. A case of microtome knives. Blood ovens: by Mr. Richards, of Richards & Company, New York City.

Dr. Love stated, concerning his exhibit: The first stage of a *Distoma* is a ciliated embryo swimming in water, and finding snakes and snails as the first hosts. Second stage, a sporocyst

containing minute creatures forming in the above hosts. Third stage, the minute creatures emerge free-swimming, and enter a second host (mollusk, fish, etc.), where they become encysted, pass out in encysted condition and enter a third host, and they then become the perfect *Distoma*, having the head in the form of a sucker and the intestine terminating blindly.

Mr. Walker explained his method of obtaining sections of diatomaceous earths: The specimens were soaked in balsam until hard, and then ground down and finished on Scotch stone like rock sections, and finally mounted in balsam.

Mr. Zabriskie remarked on his exhibit of "Bezoar stone": The specimen was two and one-quarter inches in diameter; a spherical concretion of hair covered with a black, pitted, hard calcareous coating, and was taken from a cow many years ago, he having had it in his possession for 35 years. These "stones" are said to be found in the intestines of various ruminant animals who have the habit of licking themselves. The hairs from the hide are swallowed, and sometimes become matted together as a sphere, and are coated with some calcareous matter. Good specimens have been sold for $5 to $10, to be carried in the pocket as "lucky stones." The name "Bezoar" is Persian, and signifies an expeller of poison. In ancient times these formations were said to be obtained from the Persian goat, and were highly valued as an antidote for poisons and for other medicinal purposes. They sometimes sold in the market for ten times their weight in gold.

In reply to a question by Mr. Walter H. Mead as to the experience of the members in the use of the apochromatic objectives, Mr. Richards said that the advantages of the apochromatic objectives in photography are very great, but the makers do not claim much as to their durability. Dr. Stern imported one two years ago last July, and in two months found it deteriorating; in eight months' time it was useless. Zeiss replaced this first objective, and the second soon became so poor that it was returned. Makers have tried to find some substitute for the fluorite employed in these

objectives, and Zeiss, in his new catalogue, claims to have improved his fluorite glass.

Mr. George S. Woolman said that Charles A. Spencer 25 years ago had a formula for making fluorite glass, but he rejected it on account of this certainty of deterioration.

Meeting of December 20th, 1895.

The President, Dr. Edw. G. Love, in the chair.

Forty persons present.

Mr. Walter H. Mead reported on behalf of the Committee on Nomination of Officers, renominating all the officers of the present year.

Dr. Bashford Dean addressed the Society on "European Aquaria." This address was illustrated by numerous lantern projections of instaneous photographs, obtained by himself, of various European aquaria and their contents. Dr. Dean recounted his visits to the leading aquaria of England and the Continent; the prominent experiments in the methods of retaining marine creatures in captivity; the transition from the early attempts at simulating the depths of the sea in the interior and accessories of the aquaria, to the abandonment of this endeavor in 1870, resulting in the present perfect plainness of the buildings, coupled with the near approach to the conditions of nature in the tanks; the biological work carried on in connection with these establishments; the valuable discovery of the superiority of sea water which has been stored and allowed to "rest" for a long time; and the admirable work accomplished at the aquarium at Naples—the greatest aquarium in the world.

Meeting of January 3d, 1896.

The President, Dr. Edw. G. Love, in the chair.

Twenty-three persons present.

Joseph A. Hays, Ph.D., and Mr. Alfred Douglass were elected resident members of the society.

This being the stated time of the annual election of officers of the society, Messrs. W. J. Lloyd and George H. Blake were appointed tellers of the election.

Annual reports were presented by the Treasurer, Curator, Board of Managers and Committee on Publications.

OBJECTS EXHIBITED.

Larva of Tomato Sphinx, small aquatic beetle, and young *Limulus*, all bleached in peroxide of sodium: by F. W. LEGGETT.

On the closing of the polls the following persons were declared elected officers of the society for the year 1896:

President, EDW. G. LOVE.
Vice-President, FRANK D. SKEEL.
Treasurer, JAMES WALKER.
Recording Secretary, GEORGE E. ASHBY.
Corresponding Secretary, J. L. ZABRISKIE.
Librarian, LUDWIG RIEDERER.
Curator, GEORGE E. ASHBY.
Auditors, F. W. DEVOE, F. W. LEGGETT, E. A. SCHULTZE.

In reply to a question by Mr. Walter H. Mead as to the nature and use of Klein's quartz plate, Dr. F. D. Skeel said that it is a plate of quartz 5 mm. thick, cut parallel to the axis, and used in analyzing sugars, giving the complementary colors. Mr. James Walker said that it was used also in the examination of thin rock sections.

MEETING OF JANUARY 17TH, 1896.

The President, Dr. Edw. G. Love, in the chair.

Forty-six persons present.

The President addressed the Society on "The Microscopical Identification of Starches in Food Adulteration." This address was illustrated by blackboard drawings, and by numerous mounted slides and photomicrographs of starches, and is published in abstract in this volume of the JOURNAL, p. 5.

OBJECTS EXHIBITED.

1. Many slides of various starches: by EDW. G. LOVE.
2. Many photomicrographs of the same: by EDW. G. LOVE.
3. Larva of Hawk Moth and leaf of Pink, bleached in peroxide of sodium: by F. W. LEGGETT.

MEETING OF FEBRUARY 7TH, 1896.

The President, Dr. Edw. G. Love, in the chair.

Fifty-four persons present.

Messrs. George W. Blakeslee and August Wolf were elected resident members of the Society.

Mr. Charles F. Cox addressed the Society, exhibiting and explaining the operation of Walmsley's "Autograph" Camera, and a simple apparatus for the manufacture and use of Acetylene Gas.

The subject was discussed by Dr. Love and Dr. Skeel, and an abstract of the address is published in this number of the JOURNAL, p. 35.

OBJECTS EXHIBITED.

1. Long. sect. of Kola nut.
2. Trans. sect. of do.
3. Do. stained with iodine.
4. Do. stained with hæmatoxylin.
5. Kola starch in glycerine, polarized.
6. Do. in naphthalin amber, polarized.
7. Pod of the Kola tree, entire, preserved in its natural condition.
8. Kola nuts extracted from the pod.

Exhibits Nos. 1–8: by THOS. B. BRIGGS.

9. Photomicrographs of Kola starch: by EDW. G. LOVE.

Mr. Briggs presented a very interesting description of his exhibits, being an account of the ancient and present use of the kola nut in its original habitat, Africa, by the natives for the purposes of barter, religious and social ceremonies, and especially for the purposes of resisting hunger, thirst, and fatigue. He also referred to the present cultivation and use of the true kola, *Cola accuminata* Robert Brown, in the West

Indies, and its remarkable stimulating and resistant effects upon both the black and white residents. He gave a detailed botanical account of the tree and its fruit, and the description was illustrated by an entire pod of the kola tree, preserved in its natural condition; by kola nuts extracted from the pod, and by a fine colored plate of parts of the tree, flowers and fruit.

Meeting of February 21st, 1896.

The President, Dr. Edw. G. Love, in the chair.

Nineteen persons present.

Mr. P. H. Dudley, C. E., addressed the Society on "Structure in Steel." This address was illustrated by specimens of etchings of steel under three microscopes, by 30 other specimens of steel showing structure, by 48 photomicrographs of etchings, etc, and is published in this issue of the Journal.

Meeting of March 6th, 1896.

The Vice-President, Dr. F. D. Skeel, in the chair.

Nineteen persons present.

objects exhibited.

1. Saws of Elm Saw-fly, *Cimbex americana*, mounted in balsam 20 years ago: by J. D. Hyatt.
2. Stomata of leaf of Geranium: by W. J. Lloyd.
3. Portion of an abundant mass of algæ from a tap of the Jersey City water supply: by Frederick Kato.

From the Society's Cabinet:

4. Volcanic glass, Pele's Hair.
5. Hornblendic granite, Syene, Egypt.
6. Eruptive rock altered. Matrix of opal.
7. Deep sea dredgings, China Sea.
8. "Challenger" soundings, 1,850 fathoms.

Mr. Hyatt's exhibit brought out some remarks on the durability of balsam mounts: Mr. Riederer saying that he possesses one which is thirty years old.

PUBLICATIONS RECEIVED.

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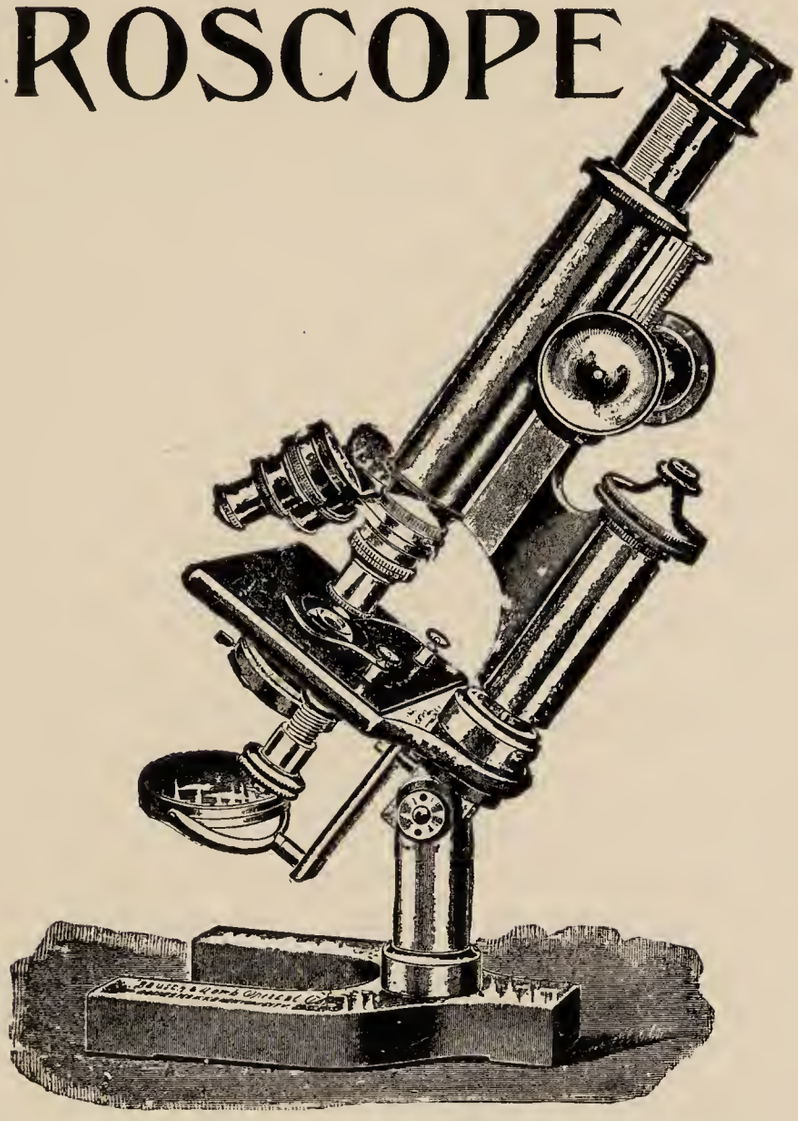

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